ISSN: 2277-3754
ISO 9001:2008 Certified
International Journal of Engineering and Innovative Technology (IJEIT)
Volume 3, Issue 3, September 2013

The Digital Energy Management of a Stand-Alone Hybrid System Photovoltaic-Wind

M. Seddik, S. Zouggar, M. Oukili, T. Ouchbel, A. Aziz, M.L.Elhafyani, F.Z.Kadda
Higher Institute of Technology EEML - BP. 473 Hay El Qods - 60000 - Oujda, Morocco

Abstract— ***In this paper, a stand-alone hybrid energy system compound of photovoltaic panels (PV), wind turbine and battery storage is proposed to feed a continuous load. Three DC-DC converters (a boost, tow Buck/boost shunt) are used with the feedback voltage control for tracking the maximum power point of PV and regulating the voltage of the DC bus at the fixed value 311V. The main objective of this work is to insure the continuous supply to the load (1.5 kW), while supervising the output power from renewable energy system and the state of charge/discharge of the battery storage. In order to make in function the complete system under the optimal conditions we propose a simple and cost-effective digital control of the energy management (based on electronic switches and dump load). The proposed system is attractive because of its simplicity and its easiness of control. The results prove that the system can guarantee the high quality power to the load, even if the weather conditions are unavailable permanently. A complete description of the energy management strategy and the system control is proposed in this document. Orcad Pspice simulation results have shown the availability and reliability of the proposed hybrid system.***

Keywords–**hybrid System, photovoltaic System, Wind system, DC-DC Converter, Energy management.**

I. INTRODUCTION

Currently, the production of domestic and industrial energy is based basically on traditional energy resources of fossil origins. This suggests that future progress of mankind will be impossible, because the energy is necessary for humanity and always will be, there is a huge correlation between lack of energy and poverty [1]-[2]. Other reason for reducing our dependence on fossil fuels is the growth of the global warming phenomena. Therefore, it is imperative to find and develop alternative energy sources to cover the energy demand of the current society while respecting the environment. Many scientific researchers were carried out in the sector of the unlimited energy sources as the wind and solar energy conversion. The Photovoltaic (PV) and the wind turbines are both the most promising energy sources due to the fact that they are free and bearable and more environmentally friendly. Today, Photovoltaic and wind generators are used in many applications such: water pumping, lighting, telecommunications and rural electrification. However, the major disadvantage of these renewable sources is their intermittent effect, I.e. risk of the non satisfaction of the load**.** This makes them unpredictable or even not very reliable to the eyes of some compared to the traditional electric energy [3]. This gap isn't relating only to the energy performance of the system, but also the lifetime of the batteries will be limited and thus we throw them very early. In general, the independent use of the two energy resources could not provide a continuous supply to the load, due to the seasonal and periodic weather changes for autonomous systems [4]. At present, the combination of renewable sources, PV and Wind, offers an excellent solution to the problems caused by the stochastic nature of these sources, using the strengths of a source to overcome the weakness of the other. The use of different energy sources can further improve the system reliability and reduced the energy storage requirements, compared to systems with only one renewable energy source [5]. For some locations, the hybrid system PV&Wind for electrical production with a storage bank offers a very reliable source of power, which is adapted to electrical loads that require high reliability [6]-[7]. Consequently, the storage systems like batteries bank or super capacitors are very important in a hybrid system PV&Wind [6]. In this paper, a hybrid energy system combining wind, PV production systems and a batteries bank is presented to ensure continuous power to stand-alone load and to reduce fluctuations in the output power. The PV and wind power are used as main (primary) energy sources, while the batteries bank is used as energy source of help (secondary). To make in function the hybrid system under the optimal conditions, on the one hand, each system is used with its individual converter by controlling the three sources independently and, on the other hand, all sources must be coupled to a bus DC of constant voltage. The DC bus feeds the DC load, knowing that AC loads are fed by an inverter. Three DC-DC converters (A Boost converter, two Buck/Boost shunt) are used with the automatic voltage control (AVC), for tracking the maximum power point of PV and to maintain the voltage DC bus to the fixed value 311V, when the renewable energy sources and the batteries are connected. In order to reach a reliable power supply, a digital control energy management *(DCEM)* for the complete system is employed, based on a simple and reliable energy management strategy (*EMS*). The main objective of *EMS* is to reassure the continuous supply to the load (1.5 kW), while supervising the output power from renewable energy system and the state of charge/discharge of the battery storage. The proposed hybrid system is established in the **Orcad/Pspice** environment.

II. PROPOSED HYBRID SYSTEM

The fig 1 represents the topology of the hybrid energy system proposed consisting of two primary sources of energies (wind and PV array), a batteries bank, *DC-DC* converters, continues load, a dump load, a digital control

ISSN: 2277-3754
ISO 9001:2008 Certified
International Journal of Engineering and Innovative Technology (IJEIT)
Volume 3, Issue 3, September 2013

energy management and a control system. The Energy sources are connected in parallel to a common DC bus through their various DC-DC converters. Each source has its individual control type feedback loop voltage (FLV). Regulating the voltage on the DC bus (Vbus) is implemented by the wind system and the batteries bank. Thus, the DC bus is regulated to a constant voltage value (311V). Continuous load is connected to the DC bus line. In order to manage the energy flow with precision, a digital control energy management and a dump load are introduced. The diodes D1 and D2 (MUR8100) [25] allow only unidirectional current source to DC bus line, thus preventing each source from acting like a load on each other. Therefore, in the failure case of any energy sources, the respective diode will automatically disconnect that source from the system.

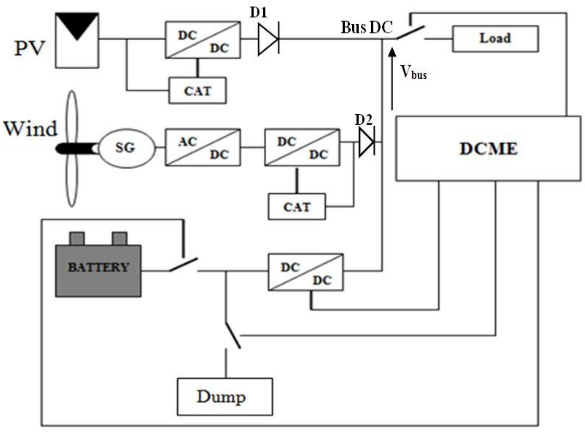

Fig.1: Hybrid Energy System Configuration.

A. *Photovoltaic System*

The Photovoltaic system becomes increasingly important as renewable energy source, because it offers many advantages such as: no fuel spawning, non-polluting, and requiring little maintenance. The PV module Mitsubishi UD180MF5 commercial was selected in this study [24]. The table I present the characteristics of the PV module given by the manufacturer at the 25°C nominal temperature. The photovoltaic system (fig.2) implanted in the environment ORCAD/PSPICE generally includes: a Photovoltaic array, a Boost, and the AVC. In this system, the photovoltaic panel is a group of 12 modules six connected in series and tow in parallel to produce a maximum power of 2.1kW at irradiance conditions of 1000W/m².

Table.I.: Electrical Characteristics of the Mitsubishi UD180MF5 PV module [24].

Parameter	Value
Number of cells	50 in series
Maximum power rating	180Wp
Open circuit voltage (Voc)	30.4V
Short circuit current (Isc)	8.03A
Maximum power voltage (Vmp)	24.2V
Maximum power current (Imp)	7.45A

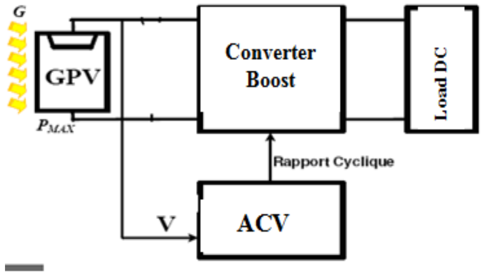

Fig.2: Chain Photovoltaic Conversion With Converter Controlled by Voltage Control:

The model of the PV cell [8]-[9] and the above data were used in the simulations to obtain the output of the solar panel characteristics. The curves of the figs 3 and 4 show the characteristics of the PV module at different intensities of solar radiation. I-V and P-V characteristics are strongly influenced by weather conditions, especially radiation and PV module temperature. For a given temperature and radiation, the P-V characteristic reaches a maximum. Therefore, it is imperative to carry out a Maximum power point tracker (MPPT) of the PV. Several MPPT techniques of photovoltaic systems have been proposed as the perturbation and observation (P&O) [10]-[11]-[12], incremental conductance (IncCond) [13]-[14], the method of short circuit (Isc) [15], and the method of open circuit voltage (Voc) [16]. In this paper the technique used is based on the automatic voltage control of the PV generator [17]. Indeed, the terminal voltage of the PV generator (Vpv) varies slightly from the illumination around the maximum power. This is why we operate the PV generator under a voltage of 145V this could be ensured by AVC (fig 9) acting on the duty cycle α of the signal controlling the interrupter of the converter (equation 1) [17]. This was chosen because of its simplicity of implementation and lower cost.

$$V_{out} = \frac{Vpv}{1-\alpha} \qquad (-1-)$$

Where the Vpv (V) is the terminal voltage of the photovoltaic generator, and Vout (V) is the output voltage of the converter.

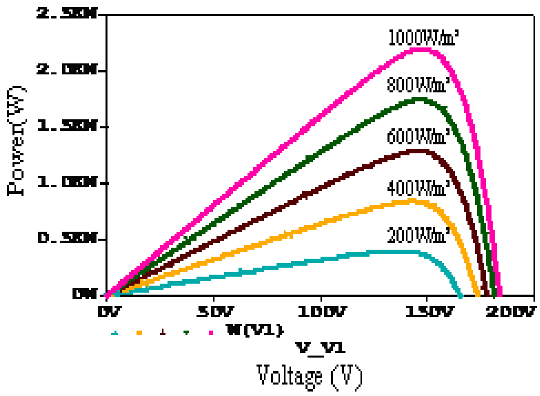

Fig.3: P-V Characteristics of PV Modules

ISSN: 2277-3754
ISO 9001:2008 Certified
International Journal of Engineering and Innovative Technology (IJEIT)
Volume 3, Issue 3, September 2013

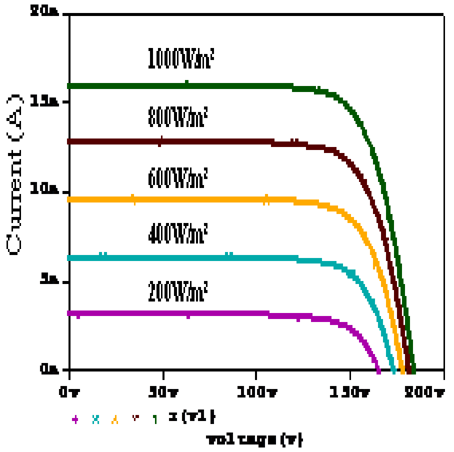

Fig.4: I-V Characteristics of PV Modules

B. *Wind System*

The windmill uses the wind kinetic energy to drive the shaft of his rotor. This one is then converted into mechanical energy which is transformed after into electrical energy. In this work we opt for self-excited induction generators (SEIG) [17]-[18]-[19].

The electric conversion chain (fig 5) implanted in the Orcad Pspice environment generally contain:

- The machine SEIG which has the following characteristics: P=1.5kW, f=50Hz, V=220/380V, Is = 4.4A, p = 2, Rs = 5.51Ω, Rr=2.24Ω, Xr = 6.9Ω, Xs = 6.9Ω, Xm = 38.81 Ω [17]-[18]-[20].
- A rectifier to six diodes for converting the AC voltage into DC voltage.
- A LC filter consisting of an L inductor in series with a C capacitor.
- An energy converter type: Buck/Boost shunts to maintain the output voltage to 311 V.
- The AVC allows regulating the desired voltage (311V) at the DC bus terminals when there is a variation of the wind speed [17]-[18]-[20]. Its principal regulation is based on the automatic variation of the duty cycle α at the proper value to obtain the desired voltage at the DC bus.

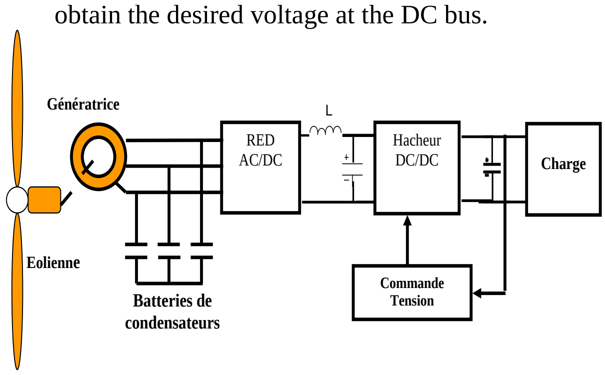

Fig.5: Synoptic Diagram of a Wind System.[17]

C. *Battery*

Most batteries used in the hybrid systems are lead-acid type. They have a long lifetime, a storage capacity and higher efficiency. What makes their use preferable compared with the other batteries types. The batteries are generally used to store electrical energy, setting the system voltage, and provide energy in case of bad climatic conditions (low wind, low radiation). Many battery models exist [21]-[22]. The most popular is the Thevenin equivalent circuit, which is illustrated in fig 6 [23]. The circuit consists of a C_{bp} capacitor, an internal resistance is represented by two series resistors (R_{bs} and R_{b1}) and a parallel resistance (R_{bp}) to the main capacitor C_{bp}. The C_{bp} capacitor represents the electrochemical energy of the battery capacity; its value is obtained from the General expression (2) of energy in a capacitor [23]. The R_{bp} resistance represents the self-discharge of the battery.

$$C_{bp} = \frac{2E_b}{(V_{\max}{}^2 - V_{\min}{}^2)} \qquad \text{(-2-)}$$

Where the E_b: is Battery energy (1000 Ah) and the V_{max}, V_{min} : is Maximum and minimum voltage supported by the capacitor C_{bp} (V_{max}=70V et V_{min}=55V).

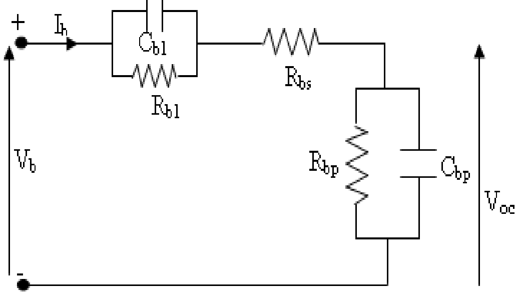

Fig.6: Equivalent Circuit of a Lead-Acid Battery [23]

For the charge and discharge of the battery, the current must be reversible. The charging current is negative and the discharging one is positive. To realize the transfer of energy in directions, a Buck / boost (shunt) converter is used (fig7). Furthermore, regulation of DC bus voltage implemented by the Buck/Boost converter and the AVC.

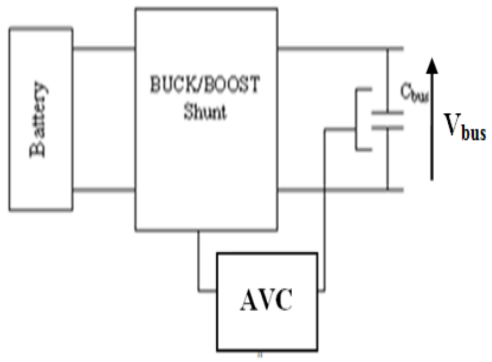

Fig.7: DC Bus Architecture With Battery and AVC

D. *The Automatic Voltage Control*

In fig 8, we represented the diagram of the automatic voltage control (AVC) [17]-[20]. This command is characterized by ease of implementation and low cost [17]. In addition, it could operate at high switching frequencies (greater than 0.1 MHz). This AVC uses the voltage at the output to search the optimal voltage be desired. The

ISSN: 2277-3754
ISO 9001:2008 Certified
International Journal of Engineering and Innovative Technology (IJEIT)
Volume 3, Issue 3, September 2013

implementation of this command involves only analog components. The dynamics of the system depends only on the delay time of the analogue components which is generally very low. The Different blocks of this command are:

- A differential amplifier
- Inverting amplifier
- A proportional–integral (PI) controller
- The integrator (RC) time constant, its role is to generate the reference voltage (V_0).
- LM319 comparator: the voltage V_0 is compared with the saw tooth signal for generating at the output of the comparator a signal modulated in pulse width and frequency of 10 kHz. This signal is supplied to the inverter MOSFET through the driver IR2111

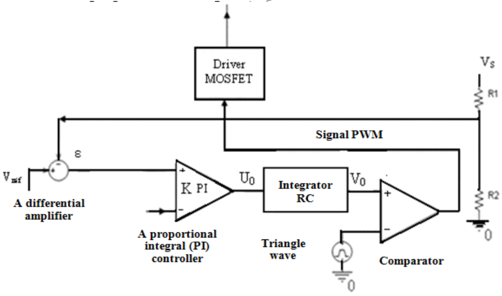

Fig.8: Synoptic Diagram of the AVC [17]

III. ENERGY MANAGEMENT STRATEGY

In order to manage the energy flow of the hybrid system, we proposed a digital control of the energy management (DCEM) for the complete system, based on a simple energy management strategy (EMS). Indeed, the PV and the wind turbine works together to respond the load demand. When the renewable energy sources are abundant (after satisfying the load demand) and the batteries bank fully charged (state1), the energy excess will be dissipated in a dump load. On the contrary, when the energy produced by the PV/Wind sources is insufficient to feed the load (1.5Kw), the battery will be delivered the energy needed to help the PV/wind to cover the load demand until the storage is exhausted (state 0). When the battery is exhausted, the battery charge becomes a priority, so all the energy produced by the PV &Wind must be transferred to the battery until it is fully charged (State1).

IV. DIGITAL CONTROL ENERGY MANAGEMENT

The fig 9 shows the DCEM proposed in this document; which is characterized by its simplicity of realization and its lower cost. The DCEM uses a power sensor, and a hysteresis comparator determines the state of charge (1) and discharge (0) of the Battery. The DCEM is usually composed by NAND, AND, NOR, EXCLUSIVE OR functions of the CMOS 4000B series**.** This latter has several advantages namely, low power dissipation (10nW), wide operating voltage range (3 to 15V), wide operating temperature range (-40 to 85 °C), a higher operating speed and an excellent noise immunity.

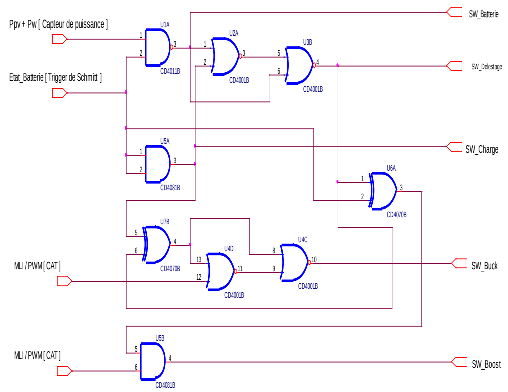

Fig.9: Digital Control Energy Management (DCEM)

V. SIMULATION RESULTS

In order to prove the reliability and the performances of the proposed hybrid system, we simulated the complete system with the Orcad-Pspice software. The hybrid system is sized to feed a DC load of 1.5kW. The load is simulated as a constant resistive load (60 Ω) connected to the fixed voltage DC bus line (311V). The first simulation of the hybrid system is achieved by varying the radiation from 500W/m² to 1000W/m², the wind speed from 0rad/s to 320rad/s and the battery state from 1 (full load) to 0 (exhausted). The figs.10 (a)-10 (c) shows the output power variation of the two sources (PV & wind), plus the total power generated by the hybrid system. The power delivered and stored by the battery bank is shown in fig 11. The load power (1,5kW) and the battery current charging/discharging) are illustrated in the figs 12 and 13. Indeed, until t=1.5s, a part of the power required by the load (fig 12) is ensured by the batteries bank (fig 11) and the I_bat current is positive (the battery discharges fig.13). At time t=1.5s, the radiation (fig 10 (a)) and the wind speed change (fig 10 (b)), and the battery takes the state 0, the power supplied by the hybrid system PV/wind (fig10.c) is completely sent to the battery bank (fig11) and the I_bat current becomes negative (battery charging fig13). Consequently, the power sent to the load becomes zero as shown in the fig.12.

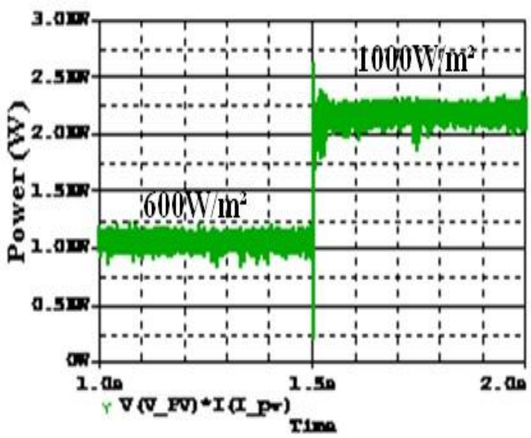

Fig 10.(a): The Output Power of the PV

ISSN: 2277-3754
ISO 9001:2008 Certified
International Journal of Engineering and Innovative Technology (IJEIT)
Volume 3, Issue 3, September 2013

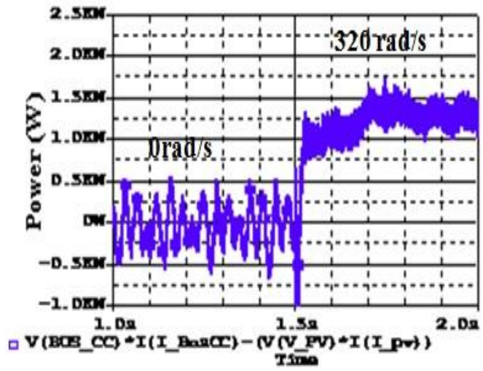

Fig 10.(b): The Output Power of the Wind

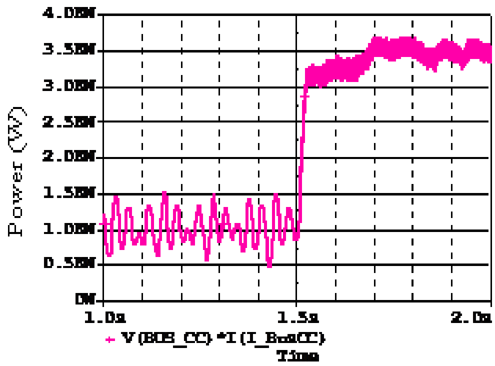

Fig 10.(c): The Power of the Hybrid System (PV&Wind)

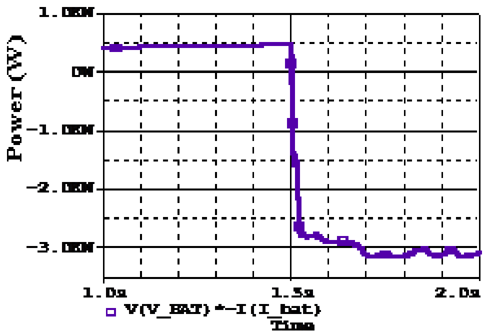

Fig.11: Provided and Stored Power by the Battery

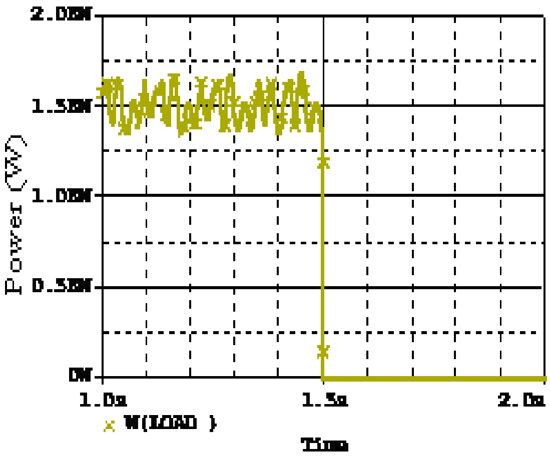

Fig.12: The Load Power

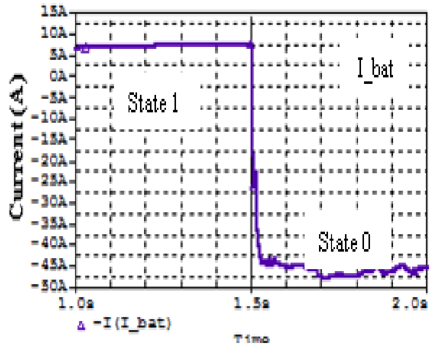

Fig.13: I_Bat Current Charging and Discharging of the Battery

The second simulation was carried out for a hybrid system to provide a constant power and to change the battery state from 0 (exhausted) to 1 (full load). The results of this test are illustrated in the figs 14 (a)-14 (b) and figs 15 (a)-15(b). The figs 14 (a)-14(b) shows the power produced by the wind and PVs, and the total output power of the hybrid system (HS) is sent to the battery bank, knowing that the figs 15 (a)-15(b) illustrates the power delivered by the HS to the resistive load and the power dissipated in a dump load. The voltage and the current of the battery which was in charge are shown in the fig 16. As we can see, until the moment t=1.52s, the power provided by the renewable sources is fully transferred to the battery (fig14.(b)) and I_bat current is negative (the battery charging state 0 fig16.(a)), thus the load power is zero (fig15.(a)). As at the moment t=1.52s the battery is fully charged (state 1 fig16.(b)), and the surplus power produced by the HS (fig14.(b)) is delivered to the dump load (fig 15.(b)).

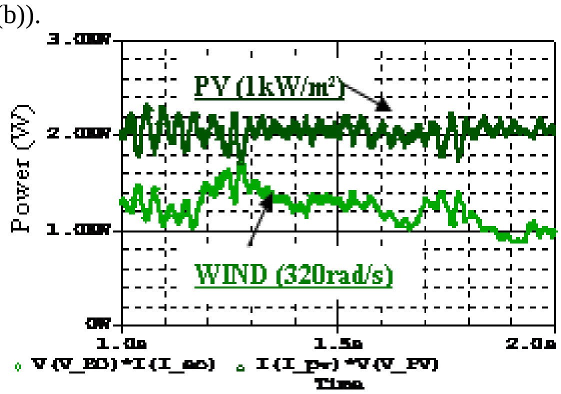

Fig.14 (a): Output Power of PV and Wind

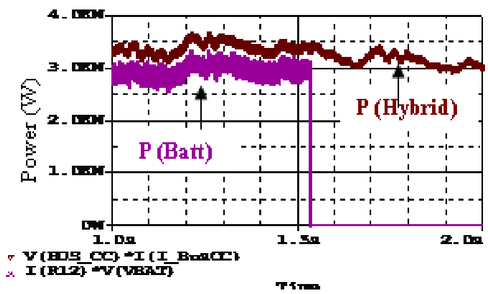

Fig.14 (b): Hybrid System Power Supplied to the Battery Bank

ISSN: 2277-3754
ISO 9001:2008 Certified
International Journal of Engineering and Innovative Technology (IJEIT)
Volume 3, Issue 3, September 2013

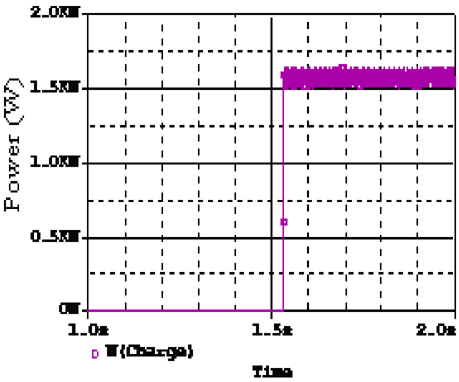

Fig.15 (a): The Power of the Load Rs

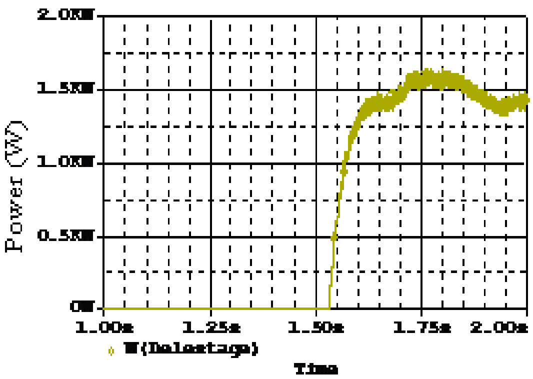

Fig.15 (b): The Power of the Dump Load

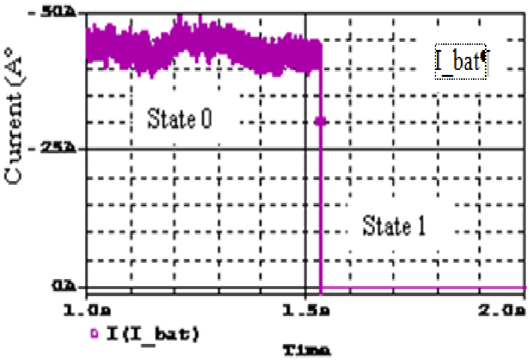

Fig.16 (a): The I_Bat Current of the Battery Charging

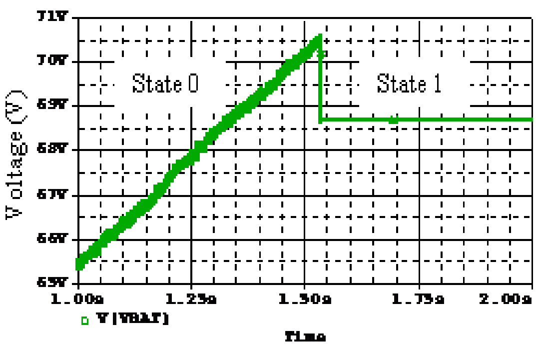

Fig.16 (b): The Voltage of the Battery Charging

In the fig 17 we presented the evolution of the DC bus voltage (Vbus) during two simulation trials. The DC bus voltage remains constant (311V), what shows excellent voltage regulation behaviour.

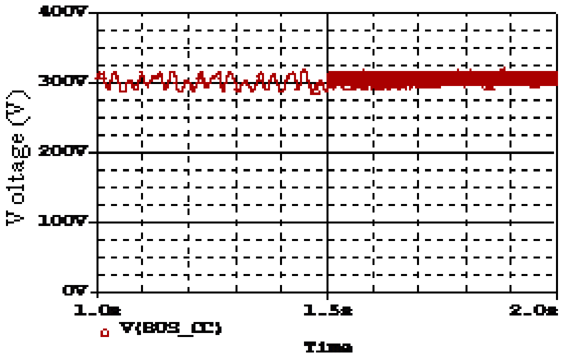

Fig.17 (a): The Voltage of DC Bus "Test 1"

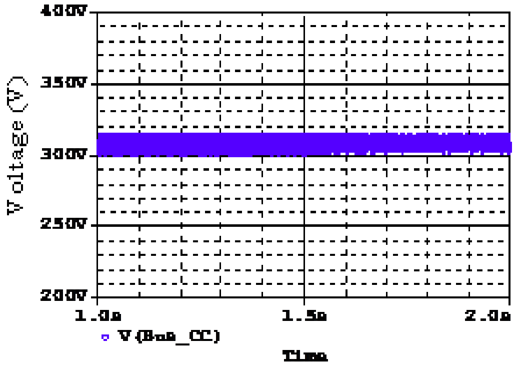

Fig.17 (b): The Voltage of DC Bus "Test 2"

VI. CONCLUSION

This article describes a digital control of the energy management for a stand-alone hybrid system, which is based on a simple and reliable energy management strategy. The hybrid system generally includes a PV panel, a wind and a bank of lead-acid batteries, which are connected to the constant voltage DC bus across the power DC-converter, these latter are controlled by an automatic voltage control. The simulation results show that the DCEM can manage the power flow produced by the hybrid system according to the State of the battery and the power requested by the load. These results confirm the feasibility and the reliability of the system suggested in this document.

REFERENCES

[1] Larry Hughes and Jacinda Rudolph "Future world oil production: growth, plateau, or peak?", Current Opinion in Environmental Sustainability 2011, 3 pp:225–234

[2] Rubbia Carlo. "Today the world of tomorrow—the energy challenge", Energy Convers Manage 47(2006), pp 2695-2697.

[3] Mitchell K, Nagria M, Rizk J. "Simulation and optimization of renewable energy systems", J Elect Power Energy Syst 2005; 27(3): pp 177–88.

[4] Yang.HX, Zhou.W, Lu.L, Fang.ZH. "Optimal sizing method for stand-alone hybrid solar-wind system with LPSP technology by using genetic algorithm", Solar Energy 2008; 82 (4): pp 354–367.

[5] Wei Zhou, Chengzhi Lou, Zhongshi Li, Lin Lu, Hongxing Yang. "Current status of research on optimum sizing of

ISSN: 2277-3754
ISO 9001:2008 Certified
International Journal of Engineering and Innovative Technology (IJEIT)
Volume 3, Issue 3, September 2013

stand-alone hybrid solar-wind power generation systems", Applied Energy 87 (2010) 380–389.

[6] Yang HX, Lu L, Zhou W. "A novel optimization sizing model for hybrid solar–wind power generation system". Solar energy 2007; 81(1): pp 76–84.

[7] Giraud F, Salameh ZM. "Steady-state performance of a grid-connected rooftop hybrid wind–photovoltaic power system with battery storage". IEEE Trans Energy Convers 2001; 16(1): pp 1–7.

[8] A.AZIZ. "Propriétés électriques des composants électroniques minéraux et organiques". "Conception et modélisation d'une chaîne photovoltaïque pour une meilleure exploitation de l'énergie solaire" Rapport LAAS N°06234 Doctorat, Université Paul Sabatier, Toulouse, 173 pages ,28 Novembre 2006 ;

[9] T. Yu, T. Chien, "Analysis and simulation of characteristics and maximum power point tracking for photovoltaic systems". in: International Conference on Power Electronics and Drive Systems, 2009, pp. 1339-1344.

[10] Zhong Zhi-dan, Huo Hai-bo, Zhu Xin-jian,Cao Guang-yi, Ren Yuan, 2008. "Adaptive maximum power point tracking control of fuel cell power plants", J. Power Sources, Vol. 176, pp. 259–269.

[11] O. Wasynczuck, 1983. "Dynamic Behavior of a Class of Photovoltaic Power Systems", IEEE Trans. Apparatus and Systems, Vol. PAS-102, No. 9, pp. 3031-3037.

[12] Chihchiang. hua, J.Lin, and C.Shen. "Implementation of a DSP-Controlled Photovoltaic System with Peak Power Tracking" IEEE transactions on industrial electronics, vol. 45, no. 1, February 1998 pp. 99-107

[13] C. R. Sullivan and M. J. Powers, "A high-efficiency maximum power point tracker for photovoltaic array in a solar-powered race vehicle," in Proc. IEEE PESC, 1993, pp. 574–580.

[14] K. H. Hussein, I. Muta, T. Hoshino, and M. Osakada, "Maximum photovoltaic power tracking: an algorithm for rapidly changing atmospheric conditions," IEE Proceedings: Generation, Transmission and Distribution, vol. 142, no. 1, pp. 59–64, 1995.

[15] T.Noguchi, S.Togashi, R.Nakamoto, 2002. "Short-Current Pulse-Based Maximum-PowerPoint Tracking Method for Multiple Photovoltaic and Converter Module System", IEEE Trans. On Industrial Electronics, Vol. 49, pp. 217-223.

[16] J. H.R.Enslin, M.S.Wolf, D.B.Snyman and W.Swiegers, 1997. "Integrated Photovoltaic Maximum Power Point Tracking Converter", IEEE Trans. on Industrial Electronics, Vol. 44, pp. 769-773.

[17] Mohammed SEDDIK, S. Zouggar, T. Ouchbel, M. Oukili, A. Rabhi, A. AZIZ, M.L. Elhafyani "A stand-alone system energy hybrid combining wind and photovoltaic with voltage control« feedback loop voltage". International Journal of Electrical Engineering IJEET, vol. 6, n°2, 2010, pp 9-13

[18] M. L. Elhafyani, S. Zouggar, Y. Zidani, M. Benkaddour "Permanent and Dynamic Behaviours of Self-excited Induction Generator In balanced mode", M.J.CONDENSED MATER, Vol 7, p49-53,2006.

[19] Eduard Mujadi, Brian Gregory, Diane Bord "Self Excited Induction Generators for Variable-Speed Wind Turbine Generation", IEEE Industry Application Conference 34 IAS Annual Meeting, pp 343-352, 3-7 October 1999 Arizona USA.

[20] M. Seddik, S.Zouggar, A.Aziz, M.L. Elhafyani, M.Oukili and T. Ouchebel "Simulation on Orcad Pspice of an Electric Chain of Conversion of the Hybrid System (Wind-PV)" IREC 09 International Renewable Energy Congress November 5-7, 2009 – Sousse, Tunisia. pp 1-7

[21] Buller Stephan, Thele Marc, Karden Eckhard, De Doncker W. Rick: "Impedance-based non-linear dynamic battery modelling for automotive applications, J. Power Sources", Vol. 113, pp. 422-430, 2003.

[22] Salameh M. Ziyad, Casacca A. Margaret, Lynch A. William: "A mathematical model for lead-acid batteries", IEEE Transactions on Energy Conversion, Vol. 7, No. 1, pp. 93-98, 1992.

[23] C.-F. Lu, C.-C. Liu and C.-J. Wu. "Dynamic modelling of battery energy storage system and application to power system stability. In IEE Proceedings Generation, Transmission and Distribution, volume 142(4), pp 429-435. IEE, Stevenage, Herts., U.K., July

[24] http://www.mitsubishielectricsolar.com/images/uploads/documents/specs/UD5_spec_sheet_175W_190W.pdf

[25] www.sirectsemi.com/pdf/MUR8100.pdf

AUTHOR'S PROFILE

SEDDIK Mohammed received Master of electronics and communication system from Faculty of Science, Mohamed I University. Oujda, Morocco in 2008. He is currently pursuing his doctorate in Laboratory of Electrical Engineering and Maintenance at Higher Institute of Technology, Mohamed I University, Oujda, Morocco. His current research interests include Hybrid system Combining Wind and Photovoltaic

Zouggar Smail was born in Casablanca, Morocco in 1963. He received Master of Engineering in Electrical Engineering from Hassania School of Public Works (EHTP), Casablanca, Morocco in 1989. In 2001 he received PhD degree in Power Electronics, from Faculty of Science, Mohamed I University. His research in renewable energy: wind power and photovoltaic systems. He is currently full Professor of Electrical Engineering, Head of Department of Applied Engineering and Director of Research Laboratory of Electrical Engineering and Maintenance at Higher Institute of Technology, Mohamed I University, Oujda, Morocco. His current research topics include theory, design, modelling, and characterization of Power Electronics, wind power and Hybrid system Combining Wind and Photovoltaic.

Abdelhak AZIZ was born in Reggada near Berkane, Morocco, in 1967. He received the ''Doctorate in sciences'' in Electronic from the University Mohamed 1er (Morocco) in 2006 and a second Doctorate from the University Paul Sabatier, Toulouse (France) in Conception of Microelectronic and Microsystems circuits in the same year. He was recruited as an assistant professor since 2007 in the Department of Electrical Engineering at Higher School of Technology Oujda and attached in

ISSN: 2277-3754
ISO 9001:2008 Certified
International Journal of Engineering and Innovative Technology (IJEIT)
Volume 3, Issue 3, September 2013

laboratory of Electrical Engineering and Maintenance. His field of research concerns the renewable energies.

Mohamed Larbi Elhafyani born in 1973, university Professor at Mohamed first university, Oujda, Morocco is currently member at Electrical Engineering and Maintenance Laboratory (LGEM). He received the "Diploma of higher studies advanced" in science from faculty of science, university Mohamed first, Oujda in 2003, He received with Honors the Ph.D degree in electrical machines & power electronic (renewable energy), from faculty of science, university Mohamed first, Oujda in 2008. Since 2009 he has been a professor of power electronic & electrical machines .His current area of interest is related to the advanced control of wind turbine system, power electric and renewable energy